Transport Phenomena
BE 373, Spring 2009
Course Syllabus

Instructor: *Samir K. Khanal*
Office: Agricultural Science 415K Telephone: 956-3812
Office Hours: Thursday 3:0 - 4:0 PM Email: khanal@hawaii.edu
& by appointment

Teaching Assistant: There will be a teaching assistant assigned for this class. If you have questions related to the material, you may request a meeting with the TA:

Devin Takara (E-mail: takarad@hawaii.edu, Ag. Sci. 415 Hallway.

Meeting Times and Locations: The classes will be held on MWF 11:30 -12:20 PM in Agricultural Science Building 204. Any change in class schedule will be announced a week in advance except for unforeseen circumstances.

Grading:		
	Exam-1:	10%
	Exam-2:	15%
	Exam-3:	15%
	Exam-4:	15%
	Final exam:	30%
	Homework:	15%

You must submit homework on due date. Fail to submit on time will be penalized unless good justification is given.

Objectives of the course: Provide engineering students the fundamentals to solve problems involving transports of momentum, energy and mass in biological, mechanical and chemical systems using a unified approach.

Textbook: No specific book will be followed in this course. Notes, handouts, and supplementary readings will be provided to the students ahead of class. Most of the notes, handouts, and supplementary readings will be posted on Laulima
https://laulima.hawaii.edu/portal
(Log on with your UH username and password)

Reference book: Geankoplis, C. J. 2003. Transport Processes and Separation Processes Principles. 4th Edition. Prentice Hall.

Prerequisites: BE 260, CEE 270, MATH 243 or 252A, CEE 320 and ME 311

Catalog Description: 3 credits. Fundamental principles and applications relating to mass, momentum, and energy transfers in biosystems and other systems for engineers and scientists.

Date	Section	Topic
	1.0	**Introduction and Basic Concepts**
1/12	1.1	General overview of transport phenomena including various applications
1/14	1.2	Transport of momentum, heat and mass , Transport mechanism, Level of transport, Driving forces
1/16	1.4	Molecular transport (diffusion), convective transport (microscopic)
1/19		**HOLIDAY: MLK Day**
	2.0	**Properties, Units and other Physical Parameters**
1/21	2.1	Unit systems, temperature, mole, concentration, pressure
1/23, 26	2.2	Gas laws, laws of conservation, energy and heat units
1/28		**First Exam**
	3.0	**Momentum Transport**
1/30	3.1	Basic concepts in fluid mechanics, Force, unit and dimensions, pressure in fluid, head of fluid
2/2	3.2	Molecular transport for momentum, heat and mass transfer
2/4	3.3	Viscosity of fluids, Newton's law, Momentum transfer, Newtonian and non-Newtonian fluids
2/6, 9	3.4	Fluid flow and Reynolds number, Overall mass balance, Control volume and Continuity equation
2/11, 13	3.5	Overall energy balance, Bernoulli's equation, Overall momentum balance
2/16		**HOLIDAY: Presidents' Day**
2/18, 20	3.6	Drag coefficient, Stokes law, Flow in packed beds, Flow in fluidized bed
2/23		**Second Exam**
	4.0	**Energy Transport**
2/25	4.1	Basic concepts in heat transfer, Heat transfer mechanisms
2/27, 3/2	4.2	Fourier's law of heat conduction, thermal conductivity, convective heat transfer co-efficient
3/4	4.3	Conduction heat transfer - through flat slab/wall and through hollow cylinder
3/6, 9	4.4	Conduction through solids in series, Forced convection heat transfer inside pipes
3/11, 13	4.5	Heat transfer outside various geometrics in forced convection,
3/16, 18	4.6	General discussion on natural convection heat transfer, Heat exchangers
3/ 20	4.7	General discussion on radiation heat transfer
3/23-27		**Spring Recess**
3/30		**Third Exam**
	5.0	**Mass Transport**
4/1	5.1	Basic concepts in mass transport, Some application examples, Modes of mass transfer
4/3	5.2	Molecular diffusion- Fick's law, Analogy between mass, heat and momentum transfer
4/6, 8	5.3	Dispersion, Hydraulic or Darcy's flow in porous media, Chemical kinetics and activation energy
4/10		**HOLIDAY: GOOD FRIDAY**
4/13, 15, 17	5.4	Film theory, Convective mass transfer, Liquid-solid mass transfer, Liquid-liquid mass transport
4/20, 22, 24	5.5	Gas-liquid mass transfer, Aeration and oxygen transport, Air stripping
4/27		**Fourth Exam**
4/29-5/6		Calculation using Mat Lab
5/11		**Final Exam**

Important Dates:

January 12 (Monday)- First day of instruction
January 19 (Monday)- Holiday: Dr. Martin Luther King, Jr. Day
January 20 (Tuesday)- Last day to drop without 'W'
January 21 (Wednesday)- Last day to add classes, or change grading option
February 16 (Monday)- Holiday: President's Day
March 13(Friday)- Last day to withdraw (with 'W')
March 23-27- Spring Recess
March 26 (Thursday)- Holiday: Prince Jonah Kuhio--day
April 1 (Wednesday)- Last day for submission of "I" removal grades
April 10 (Friday)- Holiday: Good Friday
May 6 (Wednesday)- Last day of instruction
May 11 (Monday): Final exam

Course Policies:

1. All assignments will be given during the lecture week and students will be given a week to complete. No late submission will be accepted, unless prior written permission is obtained from the instructor. For late submission, a copy of this email exchange must be attached to the front of the homework packet or it will not be graded.
2. Copying homework solutions from a copy of the solution manual or from another student is strictly forbidden and is considered cheating. First offenses will result in a grade of zero on the homework. Repeated offenses will result in a failing grade for the class.
3. Questions and intellectual discussion are strongly encouraged during the class. The course instructor and TA are available to you during scheduled office hours. The instructor and TA will answer questions by e-mail or phone, or arrange for meetings outside of class.
4. Grading is relative and is primarily judged by student's critical thinking capability. The instructor will grade all exam answer sheets to examine your understanding of subject matter. Verbose and without concise discussion will receive poor evaluation.
5. **Cell phone, computers, and other electronics** must be turned off and placed in a backpack during the entire examination. The back pack must be placed at the front of the examination room for the entire examination. Failure to do so will be considered cheating and you will receive a score of zero on the examination.
6. A student will fail for the semester for any examination incidence of cheating.
7. Talking and eating during the class is strictly prohibited.

Course Learning Objectives

Course outcome	Mastery level*	BE outcome
i) apply principles of mass/energy conservation and force balance to derive differential equations for a system	M	(a)
ii) can formulate and apply appropriate boundary/initial conditions	M	(a)
iii) understand the fundamentals of cell structure and metabolism	D	(b)

iv)	can formulate solutions relating pressure, pump power, flowrate, and conduit characteristics/dimensions in pipe flow	M	(c)
v)	understand the relationship between free energy, entropy, internal energy, and enthalpy	M	(c)
vi)	demonstrate the ability to engineer cost effective solution to control or monitor	D	(d)
vii)	design a simple experiment, with effective controls, to quantitatively measure relevant parameters	D	(e)
viii)	logically interpret data from experiments	D	(e)
ix)	apply computational tools for the solution of multidimensional and partial differential equations	M	(f)
x)	share responsibilities and duties with team members	D	(g)

† I = Introductory; D = Developmental; M = Mastery.

‡ UH Biological Engineering Course Outcomes:

a) The graduate has the ability to solve problems involving differential equations.

b) The graduate has the ability to solve physics problems involving mechanics, electromagnetics, and optics; chemistry problems involving inorganic and organic chemistry; problems involving general and micro-biology.

c) The graduate has the ability to solve engineering problems related to statics, dynamics, fluid mechanics, and thermodynamics.

d) The graduate has the ability to design a system, component, or process in which biology plays a significant role.

e) The graduate has the ability to design and conduct experiments to gather information for engineering designs.

f) The graduate has the ability to use modern engineering techniques, skills, and tools to define, formulate, and solve engineering problems.

g) The graduate has the ability to function effectively on multi-disciplinary teams.

h) The graduate has the ability to identify professional and ethical responsibilities when practicing engineering.

i) The graduate has the ability to communicate effectively in large and small groups.

j) The graduate has the background to understand the impact of engineering solutions on the surrounding context.

k) The graduate recognizes the need to engage in life-long learning through participation in professional conferences, workshops, and courses, and by reading and writing in the relevant literature.

l) The graduate has the ability to intelligently discuss contemporary issues.